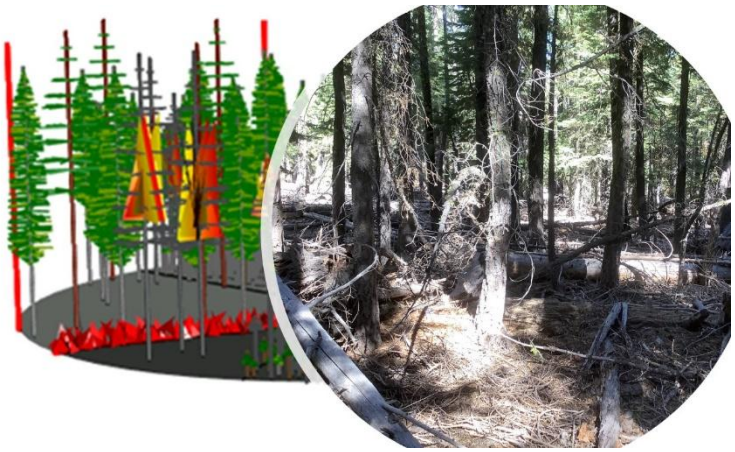
Bootsole

Fire and Fuels Report



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February 2021

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Introduction

This report describes existing and desired conditions of the forest fire and fuels resources within the Bootsole project area and the direct and indirect effects on these resources from implementing the Bootsole Project. It also documents that there would be no significant negative effects on fire and fuels resources, and therefore, no extraordinary circumstances related to these resources, resulting from implementation of the Bootsole Project. Fire and fuels resources are assessed with respect to fire behavior and stand attributes described below.

Flame Length

The predicted length of flame measured in feet. Flame length is influenced in part by fuel type, fire type (surface or crown fire), and weather conditions. Together, flame length and fuel type influence the rates at which fire lines can be safely and effectively constructed by different fire resources, including fire fighters, bull dozers, and aerially delivered fire retardant.

Less than 4 feet	Fires can generally be attacked at the head or flanks by firefighters using hand tools. Handline should hold fire.
4 to 8 feet	Fires are too intense for direct attack on the head with hand tools. Handline cannot be relied on to hold the fire. Dozers, tractors-plows, engines and retardant drops can be effective.
8 to 11 feet	Fires may present serious control problems: torching, crowning, and spotting. Control efforts at the head will probably be ineffective.
Over 11 feet	Crowning, spotting, and major fire runs are probable. Control efforts at the head of the fire are ineffective

Crowning Index,

The crowning index (CI) is a measure of the ability of a stand to sustain a fire that moves through the canopy; this is called an active crown fire. It is the 20-foot wind speed (wind speed at 20 feet above the vegetation) at which active crowning is possible, based on Rothermel's (1991) crown fire spread rate model and Van Wagner's (1977) criterion for active crown fire spread. CI is a function of canopy bulk density, slope steepness, and surface and foliar fuel moisture content (Scott and Reinhardt 2001). The higher the CI the less susceptible a stand is to an active crown fire. Reducing canopy fuels is directly correlated to an increased CI and the reduced potential for spread of active crown fire.

Torching Index,

The torching index (TI) is a measure of how susceptible a stand is to the vertical movement of fire; this is called torching or passive crown fire. It is the 20-foot wind speed at which passive crown fire (torching) is expected to initiate based on Rothermel's (1972) surface fire model and Van Wagner's (1977) crown fire initiation criteria. TI is a function of surface fuel characteristics (fuel model), surface fuel moisture content, foliar moisture content, canopy base height, slope steepness, and wind reduction by the canopy (Scott and Reinhardt 2001). The higher the TI the less susceptible a stand is to the vertical movement of fire. Reducing ladder fuels and raising the canopy base height within a stand is directly correlated to an increased TI and the reduced potential for passive crown fire.

Fire Type

The fire types modeled by the FVS Fire and Fuels Extension are:

1. Surface fires -- crowns do not burn (occur if the specified wind speed is less than the torching index and the crowning index).
2. Active crown fires -- the fire moves through the tree crowns, burning all crowns in the stand (thus killing all trees); (occur when specified wind speed is greater than the torching and crowning index).
3. Passive crown fires -- some crowns will burn as individual trees or groups of trees torch (occur when specified wind speed is greater than the torching index but less than the crowning index).
4. Conditional crown fires -- if the fire begins as a surface fire then it is expected to remain so. If it begins as an active crown fire in an adjacent stand, then it may continue to spread as an active crown fire (occur when specified wind speed is greater than the crowning index but less than the torching index). FFE models this fire type as an active crown fire, in terms of the flame lengths, mortality, and other fire effects.

Probability of Torching

The probability of torching (P-Torch) is the probability of finding a small place where torching can happen in a forest stand. For torching to occur, a surface fire must be intense enough to ignite tree crowns of smaller trees that in turn ignite the crowns of larger trees, or where large trees have long crowns that are directly ignited by the surface fire. Like TI, P-Torch requires a set of fire conditions: surface fuels, fuel moisture, and windspeed, but does not rely on an estimate of stand level canopy base height, as TI does. (Rebain et al. 2010). This is used as a proxy for the percent probability of initiation of crown fire.

Canopy Base Height

Average height from the ground to the lowest level of the forest stand's canopy. Represents the lowest height in a stand at which there is a sufficient amount of forest canopy fuel to propagate fire vertically into the canopy.

Basal Area Mortality

The potential tree mortality as measured by the percent of basal area that would be killed in a fire event as predicted by FFE (Reinhardt and Crookston 2003, Rebain et al. 2010). The probability of mortality is based on bark thickness and percent crown volume scorched, which are derived from scorch height, tree height, crown ratio, species, and tree diameter (Rebain et al. 2010). The air temperature at the time of a fire has a substantial impact on mortality as, in the model, scorch height increases exponentially with temperature.

Trees per Acre,

The number and distribution of trees per acre by diameter class is an important unit of measure because it shows the effect of treatments on different size trees. High density stands also slow the rate of fire line construction by hand crews and mechanical equipment. Data from natural stands (Dunning and Reineke 1933) indicates that for well-stocked, second-growth 100- to 150-year-old mixed conifer stands, the number of trees per acre range from 71 to 165. However, the desired trees per acre in treatment units would be lower to ensure effectiveness of the treatments for a 20-year (or longer) period.

Stand Density Index

The concept of stand density index (SDI) was first developed for even-aged stands by Reinecke (1933) to compare the density of stocking of various stands. If the SDI of fully stocked or normal density stands is known, then calculating SDI for stands of interest provides an estimate of the proportion of full stocking (Wenger 1984). Silviculturists use SDI as an index of competition in forest stands (Shaw 2006). The range of recommended SDI to sustain forest health during drought conditions in the Bootsole project area is 20-40 % of maximum SDI or 90-150 for pine-dominated stands and 115-185 for mixed pine/fir stands (Cluck 2020).

Summary of Effects

Implementation of the Bootsole Project would have no significant negative effects on the fire and fuels resources within the project area. Therefore, there would be no extraordinary circumstances related to fire and fuels resources resulting from implementation of the Bootsole Project.

Currently surface, ladder, and canopy fuels levels are high within the project area, and therefore modeled fire effects indicators suggest that if a wildfire started within the project area, much of the area would experience crown fires with high levels of mortality. Modeled fire and fuels indicators for 90th percentile weather and fire behavior conditions at time of inventory in Fall 2020 and following implementation of the Bootsole Project are shown in Table 1.

Implementation of the thinning and prescribed burning treatments planned in the Bootsole Project would result in progress toward meeting desired conditions for fire and fuels (SNFPA 2004) throughout the project area. Following treatment all fires would burn as surface fires with reduced flame lengths except for in the California spotted owl (CSO) protected activity center (PAC) where thinning treatments would be restricted to removing only ladder fuels less than six inches in diameter at breast height (DBH). Outside of the CSO PAC, modeled basal area mortality would be reduced to 20% or below, except in aspen stands where high mortality of small, young trees would be predicted; however, aspen would be expected to resprout following fire. Canopy base height and torching index would increase following treatment in all stand types, and therefore, the probability a surface fire spreading upward to the canopy, and resulting in passive crown fire, would decrease. The open wind speed at which an active crown fire is possible, or crowning index, would increase to the desired condition in all stand types except for the CSO PAC and Sierran mixed conifer stands due to higher residual canopy cover requirements. Similarly, residual tree density and stand density index would be reduced in the CSO PAC and Sierran mixed conifer stands but would remain higher than the densities required to sustain forest health during drought conditions (Cluck 2020). Tree density and stand density index would also remain higher than desired in the mechanical fuels stands where only trees <11 inches would be removed; some of these stands are much younger than 100 years old, and therefore, higher densities would be acceptable. Modeling suggests that progress toward realizing desired conditions would be maintained for at least 20 years post treatment.

Achieving the desired fire behavior conditions in the project area would provide fire suppression personnel a safer location from which to take action against a wildfire, as well as reduce expected fire intensity and severity. Suppression efficiency would be improved within the project area by creating an environment where wildfires would burn at lower intensities. Safety on roads in the project area would be improved for firefighters and public users. The treated landscape would provide a safer and more efficient environment for fire crews to take action on wildland fires that could potentially spread and destroy private property, communities, watersheds, and wildlife.

If the project were not implemented, fire and fuels indicators would remain similar to the current conditions and would be expected to diverge further from the desired conditions over time. The absence of thinning treatments and prescribed fire would allow for continued increases in the surface, ladder, and canopy fuel loading throughout the project area. Stand density index would continue to increase even as the number of trees per acre would decrease due to mortality. Down woody material would continue to accumulate at a rate that is greater than decomposition, contributing to the surface fuel layer. As the canopies of stands become increasingly dense, and surface and ladder fuel loads increase, anticipated fire behavior and effects would become more severe. These factors would contribute to an increase in the probability of stand replacement in the event of a wildland fire.

Table 1. Modeled and desired conditions of fire and fuels indicators under 90th percentile weather and fire behavior conditions at time of inventory and following implementation of the Bootsole Project (before treatment**/after treatment).**

Stand Type	Flame Length (ft)	Percent Crown Fires	Torching Prob-ability (%)	Torching Index (mph)	Crowning Index (mph)	Canopy Height (ft)	Basal Area Mortality (%)	Stand Density Index	Trees per Acre
Mechanical Thin Eastside Pine	34/ **5**	52/ **0**	42/ **2**	35/ **144**	22/ **75**	13/ **48**	66/ **9**	327/ **101**	674/ **74**
Mechanical Thin Sierran Mixed Conifer	48/ **4**	80 /**0**	56/ **1**	35/ **111**	18/ **33**	8 /**26**	84/ **20**	322/ **208**	1082/ **185**
Mechanical Thin Aspen	11/ **3**	14/ **0**	63/ **75**	73/ **na***	25 /**na***	18/ **na***	50/ **81**	364/ **204****	2119/ **1422****
Mechanical Thin Fuels	13/ **4**	25/ **0**	58/ **<1**	24/ **113**	27/ **41**	17/ **27**	62/ **15**	261/ **184**	508/ **493**
Hand Thin California Spotted Owl PAC	93/ **71**	100/ **100**	81**/ <1**	26/ **93**	9/ **11**	5/ **25**	100/ **100**	444/ **415**	685/ **665**
Desired Conditions	**<4 ft**	**0%**	**<20%**	**>30 mph**	**>35 mph**	**>20 ft**	**< 20%**	**90-185**	**71-165**

*Canopy fuels are so sparse after removal of conifers from overstory of aspen restoration stands that torching index, crowning index, and canopy height are not calculated by the model.

****Desired tree and stand densities required to sustain forest health during drought conditions apply to conifer types only.

Affected Environment

Existing Condition

Forest fuels levels in stands within the Bootsole project area range from low in plantations and open stands with a history of timber removal to abundant in areas where white fir has become established in pine stands, and white fire and lodgepole pine have encroached on aspen stands, and meadows. Photos 1 through 8 illustrate the range of forest fuels conditions in stands within the Bootsole project area.

Historically, the project area was dominated by fire-resistant, shade-intolerant eastside pine stands (Cluck 2020). Fuel levels and species less resistant to fire, such as white fir, were maintained at low levels primarily by small (100's to 1,000's of acres), lightning-ignited, surface fires that occurred with an average return interval of 30 years (LFRA 2005).

The absence of fire during the last century has allowed white fir to become established throughout the project area. Over time, dense fir regeneration beneath older stands of shade-intolerant pine has led to a shift in species composition in most stands from primarily shade intolerant pines to a mix of pine and shade tolerant white fir. Robust fir regeneration and growth has led to many of the stands within the Bootsole project being at or above desired stocking levels. These overstocked stands have exhibited elevated levels of tree mortality, caused by bark beetles during and after periods of drought, and contain high numbers of standing and down dead trees. Mortality combined with high stand density has resulted in heavy fuel loading in some areas and a corresponding increase in potential fire behavior (Cluck 2020).

The existing conditions of fire and fuels indicators and stand conditions at the time of stand inventory in 2020 were modeled using the Fire and Fuels Extension of the Forest Vegetation Simulator software, a geographic growth and yield model, and are shown in Table 1. Model outputs suggest that if a fire were to start under 90th percentile weather and fire behavior conditions many of the stands in the project area would experience crown fires. Because the windspeeds necessary to sustain an active crown fire are close to or below what would be expected under 90th percentile weather conditions (see Table 3), crown fire would be expected to spread throughout the project area. Flame lengths would be greatest in the California Spotted Owl (CSO) Protected (PAC) and shortest in stands identified for aspen restoration and mechanical fuels treatments. Wind speeds that would allow the vertical movement of fire from the understory to the canopy, i.e., torching, would be the least in eastside pine stands, Sierran mixed conifer stands, and the owl PAC making these areas the most susceptible to passive crown fire. The percent probability of initiation of crown fire ranges from 40% in eastside pine stands to 80% in the CSO PAC. Relatively low canopy base heights and the high number of small diameter trees currently present in the Bootsole project area would result in a high percentage of basal area mortality. Current stand density indices and the number of trees per acre are too high to sustain forest health during drought conditions.

Photo 1: Pine stand with thick ladder fuels in background.

Photo 2: White fir-dominated stand with beetle-killed trees.

Photo 3: Plantation with low level of surface fuels.

Photo 4: Stand with abundant standing dead and downed wood.

Photo 5:Meadow and aspen area with downed woody debris.

Photo 6: Overly dense stand with abundant fuels.

Photo 7: Stand with abundant ladder fuels.

Photo 8: Stand with low levels of forest fuels.

Desired Condition

The Bootsole Project was designed to reduce the size, intensity, and severity of fires within the Bootsole project area and increase the resilience of stands to wildfires by removing surface, ladder, and canopy fuels.

The Sierra Nevada Forest Plan Amendment (SNFPA) Final Supplemental Environmental Impact Statement (FEIS) Record of Decision (ROD) (USDA 2004) provides the primary guidance for Desired Conditions for the Fire and Fuels Resource and the Standards and Guidelines for achieving the stated Desired Conditions. Forest-wide fire and fuels management guidance from the SNFPA FEIS ROD is detailed below in addition to the desired conditions for fire and fuels in the Wildland Urban Interface (WUI) threat zone, a portion of which is in the Bootsole project area.

The Bootsole project will make progress toward achieving the following desired conditions for the WUI Threat Zone. As stated in USDA 2004 (pages 40-41), under high fire weather conditions, wildland fire behavior in treated areas within the threat zone is characterized as follows:

- flame lengths at the head of the fire are less than 4 feet;
- the rate of spread at the head of the fire is reduced to at least 50 percent of pre-treatment levels;
- production rates for fire line construction are doubled from pre-treatment levels; and
- tree density has been reduced to a level consistent with the site's ability to sustain forest health during drought conditions.

The forest-wide Standards and Guidelines for Fire and Fuels Management from the SNFPA ROD (pages 49-50) that are relevant to the Bootsole Project are as follows[1]:

1. Strategically place area fuels treatments across the landscape to interrupt fire spread and achieve conditions that: (1) reduce the size and severity of wildfire and (2) result in stand densities necessary for healthy forests during drought conditions. Complete a landscape-level design of area treatment patterns prior to project-level analysis. Develop treatment patterns using a collaborative, multi-stakeholder approach.
2. Vegetation within treatment areas should be modified to meet desired surface ladder, and crown fuel conditions as well as stand densities necessary for healthy forests during drought conditions. Site specific prescriptions should be designed to reduce fire intensity, rate of fire spread, crown fire potential, mortality in dominant and co-dominant trees, and tree density.
4. Design mechanical treatments in brush and shrub patches to remove the material necessary to achieve the following outcomes from wildland fire under 90th percentile fire weather conditions: (1) wildland fires would burn with an average flame length of 4 feet or less and (2) fire line production rates would be doubled. Treatments should be effective for more than 5 to 10 years.
5. Design a sequence of fuel reduction treatments in conifer forest types (including 3x plantation types) to achieve the following standards within the treatment area:

[1] There are no young plantations in the Bootsole project area, and therefore, point 3 from page 49 of the SNFPA FEIS ROD does not apply.

• an average of 4-foot flame length under 90th percentile fire weather conditions.

• surface and ladder fuels removed as needed to meet design criteria of less than 20 percent mortality in dominant and co-dominant trees under 90th percentile weather and fire behavior conditions.

• tree crowns thinned to meet design criteria of less than 20 percent probability of initiation of crown fire under 90th percentile weather conditions.

Additional guidance is provided in the 1988 Plumas National Forest Land and Resource Management Plan (LRMP). The general fire and fuels management direction relevant to actions proposed in the Bootsole Project is:

- On natural fuels in areas of high risk, use prescribed fire, fuel utilization, and other fuel management as needed to reduce wildfire hazard.
- Treat harvest-generated fuels both to reduce wildfire hazard and/or to facilitate cost-efficient timber production.

Environmental Consequences

Indicators for Assessing Effects

Indicators used to assess the efficacy of the proposed treatments at meeting the desired conditions are shown in Table 2. Indicators that are calculated by the FVS FFE are in bold.

Table 2. Desired conditions for fire and fuels in the Bootsole project area and corresponding indicators used to assess if these desired conditions are being met.

Desired Condition	Indicator (s)
Under 90th percentile weather and fire behavior conditions:	
Flame length less than 4 feet	**Flame length**
Rate of spread at the head of the fire is reduced to at least 50 percent of pre-treatment levels	**Composite fire and fuels indicators**
Production rates for fire line construction are doubled from pre-treatment levels	Ground fuels and small diameter trees removed
Tree density has been reduced to sustain forest health during drought conditions.	**Stand Density Index**
Surface and ladder fuels removed as needed to meet design criteria of less than 20 percent mortality in dominant and co-dominant trees under 90th percentile weather and fire behavior conditions	**Basal area mortality**
Tree crowns thinned to meet design criteria of less than 20 percent probability of initiation of crown fire under 90th percentile weather conditions.	**Probability of torching**
Treatments should be effective for more than 5 to 10 years at achieving the above conditions	Efficacy of treatments was modeled for 20 years post implementation.
Under all weather and fire behavior conditions:	
Reduce the size and severity of wildfire	**Composite fire and fuels indicators**
Complete a landscape-level design of area treatment patterns prior to project-level analysis. Develop treatment patterns using a collaborative, multi-stakeholder approach	Treatments were identified with collaborators and designed to enable implementation of prescribed burning at the landscape scale.
Site specific prescriptions should be designed to reduce fire intensity, rate of fire spread, crown fire potential, mortality in dominant and co-dominant trees, and tree density.	**Fire type, flame length, crowning index, torching index, probability of torching, canopy base height, basal area mortality, trees per acre**
On natural fuels in areas of high risk, use prescribed fire, fuel utilization, and other fuel management as needed to reduce wildfire hazard	Prescribed fire will be used. Removed fuels will be used as chips to produce clean energy.
Treat harvest-generated fuels both to reduce wildfire hazard and/or to facilitate cost-efficient timber production.	Chipping contractors will gain ownership of chipped material as partial compensation for the services provided

Methodology

The effectiveness of proposed treatments at achieving the desired conditions for fire and fuels were modeled using Forest Vegetation Simulator (FVS) and the Fire and Fuels Extension (FFE). Stands were inventoried in 2020 and thinning treatments were modeled for implementation in 2022. Prescribed burning was simulated in the spring one year post thinning, except for the owl PAC where piles were burned in 2024 followed by under burning in 2025. Simulations were run using the Scott and Burgan (2005) fuel models.

"High fire weather conditions" as stated under the desired conditions for the WUI Threat Zone were equated with the 90th percentile weather and fire behavior conditions for the forest-wide standards and guidelines. The values for the 90th percentile weather and fire behavior variables were obtained from 10 years of fire season (July 1 through October 1) data from the Remote Automated Weather Station (RAWS) nearest to the Bootsole project (Pierce); these values are shown in Table 2.

Table 3. 90th Percentile weather fuel moistures and wind speed used to model fire effects and behavior for the Bootsole Project.

Percent Moisture		Wind Speed	Temperature
1-hour fuel (0-0.25 inch)	2	20 mph	82^{o}F
10-hour fuel (0.25-1 inch)	4		
100-hour fuel (1-3 inch)	7		
> 3-inch diameter fuel	11		
Duff	10		
Live woody fuels	70		
Live herbaceous fuels	34		

Alternative 1 – Proposed Action

Direct and Indirect Effects

Thinning treatments would directly affect stand conditions, including the number of trees per acre (TPA) and stand density index (SDI), and indirectly affect modeled fire and fuels indicators.

Implementing thinning treatments proposed by the Bootsole Project would move all fire behavior and stand attributes toward the desired conditions for all stand types. The project was designed to use prescribed burning at the landscape scale and use of prescribed fire following thinning treatments would further improve progress toward meeting desired conditions for fire and fuels indicators. Progress toward achieving desired conditions would be maintained for at least 20 years post treatment. Effects of treatments are shown in Table 4 and detailed by treatment and forest type below.

Thinning and prescribed fire treatments would reduce surface, ladder, and canopy fuel loadings and would result in shorter flame lengths and increased torching index in all stand types and increased crowning indices in all but the stand types restricted by canopy cover restrictions (i.e., Sierran mixed conifer and CSO PAC). Combined, these changes would result in reduced negative fire effects and reduced potential for transition of a surface fire to a passive or active crown fire.

Predicted flame lengths would be reduced under all treatments and would range between 4-7 feet except in the CSO PAC. Flame lengths of four feet or less can be directly attacked by hand crews, and flame lengths of 4-8 feet can be directly attacked by hand crews with the support of engines, dozers, and aircraft, allowing faster fire line construction and generally resulting in less total acreage burned and safer conditions for firefighters. Except for in the CSO PAC, the Bootsole project would be successful in reducing flame lengths to levels that would allow firefighters to use direct attack methods on fires occurring within the proposed treatment areas. With the exception of the CSO PAC, all fires would be expected to burn as surface fires following treatment.

Achieving the desired fire behavior conditions in the project area would provide fire suppression personnel a safer location from which to take action against a wildfire, as well as reduce the expected fire intensity and severity. Suppression efficiency would be improved within the project area by creating an environment where wildfires would burn at lower intensities. Fire firefighting production rates would be increased because fewer ground fuels and small diameter trees would need to be cleared for Fireline construction or backfiring operations; two to four hundred trees under 5 inches DBH would be removed per acre in eastside pine, mechanical fuels and CSO PAC stands; over 700 trees per acre of this size would be removed from Sierran mixed conifer stands.

Safety on roads in the project area would be improved for firefighters and public users. The treated landscape would provide a safer and more efficient environment for fire crews to take action on wildland fires that could potentially spread and destroy private property, communities, watersheds, and wildlife.

Mechanical Thin Eastside Pine

Thinning stands to retain 30 percent of the existing basal area with the retained basal area being generally comprised of the largest trees, followed by under burning, would result in stands that meet the desired conditions for all indicators except flame length. Modeled flame lengths were reduced from 34 feet to 5 feet following treatment; flame lengths were not less than 4 feet because substantial reductions in stand density result in greater modeled wind speeds, and therefore flame lengths, in these stands. Future fires would be expected to burn as surface fires rather than active, passive, and conditional crown fires. Canopy base height was increased from 13 feet to 50 feet with the removal of ladder fuels. The probability of torching was reduced from 42% to 2% in this stand type. Torching and crowning indices increased to windspeeds of 65-155 mph. Basal area mortality was reduced from 66% to under 20 %. The number of trees per acre was reduced from 674 to 74 and stand density index declined from 327 to 100.

Mechanical Thin Sierran Mixed Conifer

Thinning stands to retain at least 40 percent of the existing basal area comprised of the largest trees while: retaining 5 percent or more of the total treatment area in trees 6 to 24 inches; and retaining at least 40% canopy would not reduce the number of trees per acre or stand density index to the desired conditions. Ladder fuels less than 6 inches would be reduced and canopy base height, and therefore torching index, would be increased. The probability of torching would be expected to decrease but would remain above desired levels. In some areas only trees less than 6 inches in diameter would be removed to meet canopy cover requirements. In other areas at least 50 percent of trees between 6 and 24 inches would be retained to meet canopy cover requirements. Flame lengths would be reduced from 48 feet to between 4 and 7 feet after thinning and prescribed burning. Fires entering the stands as surface fires would be expected to remain surface fires, however, these surface fires would result in levels of basal area mortality for dominant and codominant trees that may exceed 20%. Because of the higher residual canopy

cover requirements in this stand type (40%), the crowning index would range from 27-33 miles per hour which is less than the desired condition.

The thinning scenario described above would follow the recommendation in Cluck (2020) to manage for the pine component. White fir would be preferentially removed from stands to reduce drought-related mortality in that species. If Sierran mixed conifer stands within the project area were treated with the prescription applied to eastside pine stands, all modeled desired conditions for fire behavior and stand attributes would be met (Table 4).

Mechanical Thin Aspen

Removing conifers from within aspen stands and where aspen occurs as a minor component to restore aspen communities on the landscape would reduce flame lengths in these stands from 11 feet to 4-5 feet and would result in all post-treatment fires burning as surface fires. Canopy fuels would be so sparse after removal of conifers from the overstory that torching index, crowning index, and canopy height are not calculated by the FFE of FVS. Although calculated, torching probability is not illustrative of actual conditions as aspen stands would be comprised of small trees of relatively uniform height following thinning. The model predicts a high percent basal area mortality in treated aspen stands; aspen is susceptible to fire but would be expected to resprout following fire. Tree density would be reduced from 2,119 trees per acre to 1,426 trees per acre; residual stand densities would be comprised of small aspen trees. The stand density index after thinning of 190 would be approximately 34% of the maximum SDI (562) for aspen.

Mechanical Thin Fuels

Removing forest fuels less than 11 inches in diameter from select stands would result in these stands meeting the desired conditions except with respect to stand density index. Modeled SDI increases above 150 following thinning because only the smallest trees would be removed from stands with an otherwise fairly narrow diameter distribution. The desired number of trees per acre is for stands 100-150 years old and the majority of stands identified for mechanical fuels treatment are much younger.

Hand Thin California Spotted Owl PAC

Hand thinning to remove fuels less than 6 inches DBH from the CSO PAC would remove ladder fuels thereby increasing the canopy base height and increasing the windspeed at which a surface fire would be predicted to move vertically via ladder fuels to the canopy. The probability of torching would also be reduced. Tree density and SDI would exceed the levels consistent with the site's ability to sustain forest health during drought conditions. Fires entering the PAC as surface fires would be expected to remain as surface fires. However, the modeled crowning index would be very low (9-11 mph) in the PAC and if fires were to encounter the dense canopy of the PAC as crown fires, they would be expected to burn as stand-replacing crown fires (i.e., with 100% basal area mortality).

Direct and Indirect Effects of Prescribed Fire Only

Prescribed fire alone would be applied to approximately 463 acres. Prescribed fire would directly remove surface fuels and small ladder fuels thereby indirectly reducing flame lengths, probability of crown fire, and basal area mortality from fires burning at high ambient temperatures during the fire season. This treatment would be less effective at reducing crown density and height to live crown than treatments with a thinning component, however stands proposed for this treatment generally have less dense overstories. Without tree removal, treatments would be less effective over the long term as trees die and ground and ladder fuels accumulate.

Table 4. Modeled fire and fuels indicators under 90th percentile weather and fire behavior conditions at time of inventory in Fall 2020 and for 20 years following implementation of the Bootsole Project[2].

Stand Type	Year	Flame Length (ft)		Percent Crown Fires		% Probability Torching		Torching Index (mph)		Crowning Index (mph)	
		Bootsole	***No Action***	***Bootsole***	***No Action***	***Bootsole***	***No Action***	***Bootsole***	***No Action***	***Bootsole***	***No Action***
Mechanical Thin Eastside Pine	2020	34	34	52	52	42	42	35	35	22	22
	2022	7	36	0	76	8	43	65	35	71	22
	2023	5	38	0	78	2	44	144	32	75	22
	2027	5	33	0	56	2	42	130	33	72	23
	2032	5	39	0	56	2	39	142	33	70	23
	2042	5	39	0	44	1	27	155	58	67	25
Mechanical Thin Sierran Mixed Conifer 2nd set of numbers is modeled results with pine prescription	2020	48	48	80	80	56	56	35	35	18	18
	2022	16/6	50	20/0	100	34/22	74	40/66	15	27/70	17
	2023	4/4	58	0/0	100	1/5	66	111/178	9	33/73	17
	2027	7/5	66	0/0	100	34/3	63	50/149	11	31/71	16
	2032	7/4	70	0/0	100	24/4	52	59/158	13	30/68	15
	2042	5/4	71	0/0	100	<1/<1	48	108/182	21	29/66	15
Mechanical Thin Aspen	2020	11	11	14	14	63	63	73	73	25	25
	2022	4	16	0	43	80	79	N/A*	29	N/A	20
	2023	3	18	0	57	75	82	N/A	24	N/A	20
	2027	4	29	0	71	61	81	N/A	27	N/A	19
	2032	5	34	0	71	78	78	N/A	30	N/A	19
	2042	5	25	0	29	56	77	N/A	47	N/A	19
Mechanical Thin Fuels	2020	13	13	25	25	58	58	24	24	27	27
	2022	6	12	0	25	30	37	55	50	37	26
	2023	4	14	0	25	<1	44	113	44	41	26
	2027	5	12	0	12	9	25	71	80	40	26
	2032	5	18	0	25	3	7	100	120	40	27
	2042	5	20	0	25	5	9	98	106	42	31
Hand Thin California Spotted Owl PAC	2020	93	93	100 CC**	100 CC	81	81	26	26	9	9
	2022	90	95	100 CC	100 A**	44	85	39	10	9	9
	2024	71	98	100 CC	100 A	<1	90	93	6	11	9
	2027	81	101	100 CC	100 A	10	86	53	9	11	9
	2032	85	105	100 CC	100 A	<1	95	68	9	11	9
	2042	91	110	100 CC	100 CC	<1	60	89	24	11	9

*Canopy fuels are so sparse after removal of conifers from overstory that torching index, crowning index, and canopy height are not calculated by the model.
**Without treatment, the fires in the CSO PAC would burn primarily as active (A) crown fires killing all trees. With treatment fires would burn as conditional crown fires (CC) meaning that if a fire begins as a surface fire then it is expected to remain so; if the fire begins as an active crown fire in an adjacent stand, then it may continue to spread as an active crown fire.

[2] Stands were inventoried in 2020 and thinning treatments were scheduled in 2022. Prescribed burning was simulated in the spring one year post thinning, except for the owl PAC where piles were burned in 2024 followed by under burning in 2025.

Table 4 (continued)

Stand Type	Year	Canopy Base Height (ft)		Basal Area Mortality %		Stand Density Index		Trees per Acre	
		Bootsole	***No Action***	***Bootsole***	***No Action***	***Bootsole***	***No Action***	***Bootsole***	***No Action***
Mechanical Thin Eastside Pine	2020	13	13	66	66	327	327	674	674
	2022	46	11	22	79	99	337	74	657
	2023	48	11	9	78	101	341	74	647
	2027	50	12	8	63	102	359	53	611
	2032	52	14	7	65	114	375	53	555
	2042	53	19	6	52	138	392	53	452
Mechanical Thin Sierran Mixed Conifer 2nd set of numbers is modeled results with pine prescription **r**	2020	8	8	84	84	322	322	1082	1082
	2022	22/50	4	49/32	98	205/105	342	185/87	1067
	2023	26/51	3	20/11	99	208/108	350	185/87	1052
	2027	30/53	4	47/10	99	186/109	385	123/64	1006
	2032	35/53	6	41/9	99	206/121	421	122/64	945
	2042	41/55	10	14/7	83	244/145	472	120/64	782
Mechanical Thin Aspen	2020	18	18	50	50	364	364	2119	2119
	2022	N/A	9	69	72	190	392	1426	2092
	2023	N/A	9	70	81	204	402	1422	2065
	2027	N/A	11	70	85	244	438	1391	1977
	2032	N/A	13	76	87	276	471	1357	1860
	2042	N/A	18	73	76	322	507	1263	1620
Mechanical Thin Fuels	2020	17	17	62	62	261	261	508	508
	2022	26	16	43	50	108	279	117	500
	2023	27	17	15	66	184	285	115	493
	2027	28	20	20	50	183	308	97	465
	2032	31	22	10	37	200	325	90	416
	2042	36	28	16	33	222	330	76	307
Hand Thin California Spotted Owl PAC	2020	5	5	100	100	444	444	685	685
	2022	22	4	100	100	397	463	347	674
	2024	25	5	100	100	415	470	345	665
	2027	29	6	100	100	346	500	257	637
	2032	35	7	100	100	382	531	253	599
	2042	45	11	100	100	453	596	245	542

Alternative 2 – No Action

Direct and Indirect Effects

The absence of thinning treatments and prescribed fire would allow for continued increases in surface, ladder and canopy fuel loading throughout the project area. Stand density index would continue to increase even as the number of trees per acre would decrease due to mortality. Down woody material would continue to accumulate at a rate that is greater than decomposition, contributing to the surface fuel layer. As stand canopies become more dense, and surface and ladder fuel loads increase, anticipated fire behavior and effects would become more severe. These factors would cause an increase in the probability of stand replacement in the event of a wildland fire.

Under 90th percentile weather conditions, predicted flame lengths in a wildland fire would be in excess of 11 feet throughout most of the project area (Table 4). When flames lengths exceed 11 feet, crowning, spotting, and major fire runs are probable and control efforts at the head of the fire are ineffective. Predicted flame lengths would be shortest in stands targeted for aspen restoration and in mechanical thin fuels plots; however, flame lengths in these stand types would still range between 11 and 34 feet.

Flame lengths are predicted to be close to 40 feet in eastside pine stands, 50 feet in Sierran mixed conifer stands, and close to 100 feet in the CSO PAC (Table 4). Low crowning indices would promote canopy fire spread; most fires would burn as crown fires with high levels of basal area mortality. These predicted flame lengths would create situations where direct Fireline attack would be prohibited and firefighters would have to employ indirect suppression methods. Furthermore, fires burning under 90th percentile fire weather in these stand types could result in a wildland fire of large size and severe negative environmental effects. Under the predicted severe burning conditions, a fire could remove or destructively alter soil organic matter, volatize nutrients, decrease water-absorbing capacity, and kill living plant parts and microorganisms (Brown et al. 2003).

The potential severe fire behavior could lead to increased risk to fire fighters, public users, resources (e.g., biological, ecological, and watershed), and private property that is adjacent to the project area within the WUI. Lives, property, and natural resources in and around the WUI would continue to be at risk from wildland fires that have the potential to be both large in size and damaging to the ecosystem well beyond the scope of what occurred in the area historically. Twenty years in the future, these conditions would continue, and likely worsen, without some type of fuels reduction treatment or other disturbance (e.g., prescribed fire) to reduce fire hazard in the area.

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